DOCUMENT RESUME

ED 285 549 IR 012 754

AUTHOR Mathison, Carla; Allen, Brockenbrough S.
TITLE The Effect of Stories and Diagrams on Solution of an Analogous Problem.
PUB DATE Feb 87
NOTE 9p.; Paper presented at the Annual Convention of the Association for Educational Communications and Technology (Atlanta, GA, February 26-March 1, 1987). For the complete proceedings, see IR 012 723.
PUB TYPE Information Analyses (070) -- Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Mapping; Comparative Analysis; *Diagrams; Graduate Students; Higher Education; Hypothesis Testing; *Intermode Differences; *Logical Thinking; Prior Learning; *Problem Solving; *Transfer of Training
IDENTIFIERS AECT Research and Theory Division Meeting; *Analogies

ABSTRACT

The hypothesis for this study assumed that subjects who received a diagram representing the structural relationships of a story would be more likely to solve a new and analogous problem than subjects who received two analogs without a diagram. The 151 graduate students who acted as subjects were randomly assigned to one of four treatments: one or two analogs, with or without a diagram. Learners receiving the diagram were asked to copy it, to think about it while reading the story, and to rate its usefulness. The learners' solutions to a new analogous problem were then judged as correct or incorrect. No significant differences were found between groups receiving one or two story analogs, although a significantly higher percentage of subjects receiving the diagram were able to solve the problem. It was concluded that interaction with a diagrammatic representation greatly facilitated the transfer of solutions to an analogous problem and that, although multiple similar problem-solving experiences may help learners solve new problems analogically, the key variable is not the number of experiences, but the manner in which they are presented and processed. A list of 26 references is provided. (MES)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED285549

Title:

The Effect of Stories and Diagrams on Solution of an Analogous Problem

Authors:

Carla Mathison
Brockenbrough S. Allen

BEST COPY AVAILABLE

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Michael R. Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

IR012 754

The Effect of Stories and Diagrams on Solution of an Analogous Problem

Carla Mathison
Brockenbrough S. Allen
Department of Educational Technology
San Diego State University
San Diego, CA 92182-0311

The Effect of Stories and Diagrams on Solution of an Analogous Problem

Carla Mathison and Brockenbrough S. Allen
Department of Educational Technology
San Diego State University

Reasoning by analogy pervades everyday living and learning. We draw on past experiences to help us understand new situations. Counseling a friend, we think of how we felt in a similar situation. Deciding on which dishwasher to buy, we consider criteria used for other household appliance purchases. We transfer our knowledge about how to solve a particular geometry problem to a new setting involving architectural design. We examine the industrial revolution for clues about the future of on our own revolution in communications. As Oppenheimer noted, "analogy is inevitable in human thought" (1956, p. 129).

Background

Analogical reasoning is not necessarily spontaneous. Recognizing and applying past experience and knowledge to new situations involves a complex set of cognitive processes that include abstraction, subsumption, and domain integration. There is strong support for the effectiveness of formal training in deeper levels of analogical processing (Dreistadt, 1969; Gabel & Sherwood, 1980; Jorgenson, 1980; Reigeluth, 1983; Royer & Cable, 1976; Schustack & Anderson, 1979; Winn, 1982). Interest in analogical transfer in problem-solving activity goes as far back as Esher, Raven & Earl (1942). More recent work includes Hayes & Simon (1977); Reed, Ernst & Banerji, (1971); Rumelhart & Abrahamson (1973); and Sternberg (1977a, 1977b).

Gentner (1983) proposes "structure-mapping" as technique for understanding analogies. She distinguishes analogies from other types of comparisons, defining an analogy as " . . .a comparison in which relational predicates, but few or no object attributes can be mapped from base [the familiar] to target [the new]" (p. 159). The strength of a specific structural relationship is determined by the number and degree of smaller, interconnecting relationships which it subsumes. Gentner also uses structure mapping to describe the fundamental elements of simple analogical reasoning. The process depends on three basic mapping "rules": 1.) Discard attributes of objects; 2.) Try to preserve relations between objects. 3.) Decide which relations are preserved; choose system of relations (Systematicity Principle).

Effect of Prior Knowledge on New, Analogous Problems

Gick and Holyoak (1983) investigated the factors that underlie spontaneous recognition of analogies between prior knowledge/experience and new problem situations. They were particularly concerned with what they term semantically disparate problems—situations in which prior knowledge has few surface similarities with the new situation.

Gick and Holyoak have found that learners are more likely to recognize prior knowledge and experiences as relevant to a new problem if they have acquired a schema that is more abstract or more general than the several individual experiences that are each relevant to the problem. The assumption is that exposure to two or more analogous situations induces a "convergent" schema by encouraging

the learner to "map" the analogs and abstract the similarities in fundamental structure.

Unresolved Issues

A close examination of Gick and Holyoak's methodology in experiment 4 (1983) raises several issues. Gick and Holyoak found that when learners were given two analogies prior to a new problem they were much more likely to spontaneously recognize and apply prior knowledge than when they were given only one analogy. However, the conditions under which these two groups initially learned their respective analogies were very different.

Subjects in the two-analogy group were given two analogous stories involving problem-solving and were asked to: 1.) read each story, 2.) summarize it, 3.) rate its comprehensibility, and finally, 4.) describe, in writing, the similarities between the two stories. Immediately following this last activity, subjects were given the new problem and asked to solve it. Subjects in the one-analogy group were given one story that was analogous to the new problem and one disanalogous story. The subjects were then asked to perform the same four activities and to solve the new problem.

Consider Step 4, in which learners were asked to "map" similarities between the two stories. Gick and Holyoak hypothesized that instructions to find similarities would encourage subjects in the two-analogy group to identify and abstract relationships relevant to the new problem. However, this instruction may have had an unintentional and opposite effect on the one-analogy group. Struggling to find similarities between two disanalogous stories may have led these subjects to distort their representation of the relationships in the analogous story to such an extent that they were then unable to recognize its similarities to the new problem.

Research Questions

Is it possible that, under different circumstances, exposure to a single analog prior to the problem-solving task could yield more favorable results? This question is important for what it implies about the cognitive processes involved in analogical reasoning and for what it suggests about how to use instructional techniques to promote these processes. Must learners encounter multiple analogs in order to develop a general schema that can be transferred to future problems? Or, is a single analog sufficient assuming that learners are helped to identify fundamental structural relationships. The hypothesis for the current study assumed that subjects who received a diagram representing the structural relationships of the story would be more likely to solve a new and analogous problem than subjects who received two analogs without a diagram.

Experiment Design

The subjects were 151 post-baccalaurate students enrolled in a fifth-year teacher education program. The experiment employed a 2 X 2 factorial design: The first independent variable was the number of story analogs; the second independent variable was the type of instruction accompanying the story analogs (diagram vs. no diagram). The dependent variable was performance on a new problem-solving task.

Story Analogs. These stories were adapted from those used by Gick and Holyoak. Each story described a goal, resources, constraints, and a solution. One story told about neighbors who put out a fire by encircling it and dousing it with small buckets of water. The other described how an army faced with narrow roads

then attacked a fortress in small groups from many directions at once. The basic principle underlying both stories was as follows:

> sometimes, when it is impossible to attack a target with a large force from one direction, it may be better to disperse forces and attack from many directions simultaneously.

This principle is the only one which yields a satisfactory solution to the analogous problem used for the outcome measure. Students were asked how they would use "laser" rays to destroy a malignant stomach tumor . They were told that one high-intensity laser beam would destroy the tumor but would also destroy intervening tissue. They were also told that low-intensity beams are harmless to healthy tissue. No hint was given to as to the analogous relationship between the stories and the new problem.

Diagrammatic Representation. The diagram--also adapted from Gick and Holyoak--represented this principle in visual form accompanied by a text statement of the principle (see figure 1). Learners were asked to copy the diagram in a provided space and then asked to read the story analog.

The most important changes in the original Gick and Holyoak stories involved the insertion of a cue that asked subjects to think about the diagram as they read the story. (Subjects who did not receive the diagram did not receive this cue.)

Learners who did not receive the diagram were asked to rate the stories in terms of ease of understanding. Learners who did receive the diagram were asked to rate the diagram's usefulness in explaining the problem encountered in the stories. All learners were then given the new problem and asked to solve it.

Procedures

Treatments were administered in booklet form to six intact college classes. A table of random numbers was used to assign booklets to subjects. Subjects were instructed orally to proceed through the booklet in a linear fashion and to read written instructions carefully. Booklets were collected 30 minutes later.

Analysis of Data

Learners' solutions to the new problem were judged by two independent readers as either correct or incorrect. To be judged correct, a solution had to include a 'dispersion' strategy similar to that found in the story analogs. That is, it had to include a reference to simultaneous application of smaller forces from multiple directions.

Results

Scores were converted into percentages and submitted to a chi square analysis. Table 1 shows the percentage of correct solutions across all treatment groups.

Percentage (Numbers) of Correct Solutions
Across All Treatment Groups

	WITHOUT Diagram	WITH Diagram
One-Story Analog	5.1% (2) N=39	61.1% (22) N=36
Two-Story Analogs	13.5% (5) N=37	69.2% (27) N=39

TABLE 1

Of the 151 subjects, 36% (55) produced the correct solution to the problem. The effect of the number of story analogs on solution production was estimated by comparing the scores of students who received one story analog with the scores of students who received two analogs (see Table 2) This comparison revealed no significant difference.

Percentage (Number) of Correct Solutions For Subjects
Receiving One and Two Story Analogs

	One Analog	Two Analogs
Correct Solutions	42% (24)	57.2% (32)

TABLE 2

Table 3 presents an analysis of the effect of the diagram on the solution rate. Of the subjects receiving the diagram, 65% were able to solve the new problem compared to only 9% of those who received no diagram. This distribution was significant at the .01 level.

Percentage of Correct Solutions

	WITH Diagram	WITHOUT Diagram
Correct Solutions	65.3% (49)	9.2% (7)

TABLE 3

The results support the hypotheses of this study. The data indicate that the number of story analogs received by subjects had no effect on in their success in solving an analogous problem. Interaction with a diagrammatic representation, however, greatly facilitated the transfer of solutions to the analogous problem.

Discussion

This study does not necessarily argue against multiple analogies as a means for promoting convergent schema nor does it argue against multiple analogies as a tool for promoting analogical transfer. Gick, Holyoak, and others provides substantial evidence that exposure to multiple analogs can lead to such schema building. However, learners in the treatment group that was most successful in the Gick and Holyoak (1983) study received more than a mere presentation of story analogs: they were directed to interact with the stories—asked to write down the similarities between the two problem situations.

In the present study, the focus of activity was on interaction with the diagram (copying it) and on interaction with the diagram and the analogous stories (cues to think about the relationship between the diagram and stories; requests to rate the usefulness of the diagram in explaining the problem in the story). The findings suggest that processing activity and orienting messages may are at least as important as a means for inducing convergent schema and promoting analogical processing as is the number of analogs. In the present study, when learners were given two stories but no direction to interact with the text or diagram, they had little success in solving the new problem. This finding suggest that, although multiple similar problem-solving experiences may help learners solve new problems analogically, the key variable is not the number of experiences but the manner in which they are presented and processed.

REFERENCES AND BIBLIOGRAPHY

Anderson, J. R. (1976). Language, memory, and thought. Lawrence Erlbaum Associates, Hillsdale, N. J.

Anderson, R. C. & Pichert, J. W. (1978). Recall of previously unrecallable information following a shift in perspective. Journal of Verbal Learning and Verbal Behavior, 17, 1-12.

Carbonell, J. G. (1983). Learning by analogy: Formulating and generalizing plans from past experience. In R. S. Micalski, J. G. Carbonell, & T. M. Mitchell (Eds.), Machine Learning: An artificial intelligence approach. (pp. 137-59), Palo Alto, California: Tioga Publishing Company.

Gentner, D. (1983). Structure-mapping: Atheoretical framework for analogy. Cognitive Science, 7, 155-70.

Gick, M. L. & Holyoak, K. J. (1980). Analogical problem solving. Cognitive Psychology, 12, 306-55.

Gick, M. L. & Holyoak, K. J. (1983). Schema induction and analogical transfer. Cognitive Psychology, 15, 1-38.

Hayes, D. A. & Mateja, J. A. (April, 1981). Long term transfer effect of metaphoric allusion. Paper presented at the Annual Meeting of the American Educational Research Association, Los Angeles, Ca.

Jensen, J. V. (1975). Metaphorical constructs for the problem-solving process. Journal of Creative Behavior, 9, 113-24.

Jorgenson, S. (1980). Using analogies to develop conceptual abilities. Paper presented at Annual Meeting of the Association for Educational Communications and Technology, (EDRS Document Reproduction Service No. ED192820), Denver, Co.

Oppenheimer, J. R. (1956). Analogy in science, American Psychologist, 12, 127-35.

Petrie, H. G. (1979). Metaphor and Learning. In A. Ortony, Metaphor and thought. Cambridge: Cambridge University Press.

Reed, S. K., Ernst, G. W., & Banerji, R. (1974). The role of analogy in transfer between similar problem states. Cognitive Psychology, 6, 236-50.

Roediger III, H. L. (1980). Memory metaphors in cognitive psychology. Memory & Cognition, 8, 231-46.

Royer, J. M. (1979). Theories of the transfer of learning. Educational Psychologist, 14, 53-69.

Royer, J. M. & Cable, G. W. (1976). Illustrations, analogies, facilitative transfer in prose learning. Journal of Educational Psychology, 68, 205-09.

Rumelhart, D. E. & Abrahamson, A. A. (1973). A model for analogical resoning. Cognitive Psychology, 5, 1-28.

Rumelhart, D. E. & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (eds.), Schooling and the acquisition of knowledge. Hillsdale, N. J.: Erlbaum Associates.

Rumelhart, D. E. (January, 1981). Understanding understanding. University of California, San Diego: Center for Human Processing, (Report No. 8101).

Rumelhart, D. E. & Norman, D. A. (1981). Analogical processes in learning. In J. R. Anderson, (Ed.), Cognitive skills and their acquisition. Hillsdale, N. J.: Erlbaum Associates.

Schustack, M. W. & Anderson, J. R. (1979). Effects of analogy to prior knowledge on memory for new information. Journal of Verbal Learning and Verbal Behavior, 18, 181-201.

Simon, H. A. (1978). Information-processing theory of human problem solving. In W. K. Estes (Ed.), Handbook of learning and cognitive processes. Hillsdale, N. J.: Erlbaum Associates.

Sternberg, R. (1977a). Component processess in analogical reasoning. Psychological Review, 84, 353-79.

Sternberg, R. (1977b). Intelligence, information processing, and analogical reasoning: The componential analysis of human abilities. Hillsdale, N. J.: Erlbaum Associates.

Tourangeau, R. & Sternberg, R. (1981). Aptness in metaphor. Cognitive Psychology, 13, 27-55.

Tversky, A. (1977). Features of similarity. Psychological Review, 84, 327-50.

Winston, P. H. (1970). Learning structural descriptions from examples. (Rpt. AITR-231), Cambridge, Mass.: MIT, Artificial Intelligence Laboratory.